



Land use and fertilisation affect priming in tropical andosols

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ABSTRACT

Input of available carbon and/or mineral fertilisation can accelerate mineralisation of soil organic matter i.e. priming effect. However, studies to priming effects in andic soils are absent despite their unique physicochemical and biological properties. Nutrients and ^{14}C labelled glucose were added to Andosols of Mt. Kilimanjaro from six ecosystems: (1) savannah (2) maize fields (3) lower montane forest (4) coffee plantation (5) grasslands and (6) Chagga homegardens. Carbon-dioxide production was measured for 60 days. Maximal and minimal mineralisation rates immediately after glucose additions were observed in lower montane forest with N + P ($9.1\% \pm 0.83 \text{ d}^{-1}$) and in savannah with N ($0.9\% \pm 0.17 \text{ d}^{-1}$), respectively. Land use significantly influenced glucose induced priming effect measured as additional CO_2 compared to unfertilised soil. Variations of the priming effect in land use without fertilisation are attributed to differences in microbial biomass content. Depending on land use, nutrient addition increased or decreased glucose induced priming effect. Maximal and minimal priming effect were observed in grassland soils ($0.171 \text{ mg C-CO}_2 \text{ g}^{-1} \text{ soil}$) with P and in soils under maize fields ($0.009 \text{ mg C-CO}_2 \text{ g}^{-1}$) fertilized with N, respectively. Microorganisms in Chagga homegarden soils incorporated the highest glucose percentage ($6.47\% \pm 1.16$), which was 3 times higher compared to grassland soils ($2.18\% \pm 0.39$). 50–60% of the ^{14}C input was retained in bulk soil. Land use and fertilisation (N and P) affected priming in Andosols. Andosols occurring at Mt. Kilimanjaro, especially those under the Chagga homegardens shows great potential for soil C sequestration.

1. Introduction

Soil organic matter (SOM) constitutes the largest proportion of organic C on earth's surface and plays a critical role in controlling greenhouse gases emissions, C sequestration and soil fertility [26]. Maintaining an adequate level of SOM should be the guiding principle to ensure ecosystem functionality and sustainable soil fertility. This is especially true and significant in environments where highly weathered and nutrient poor soils are often managed with few external inputs. Plant residues inputs provide the primary raw materials for SOM formation. However, release of organic substances by living plants in soil e.g. root exudates and litter can accelerate the mineralisation of native SOM by inducing fast C turnover in the vicinity of the roots [41]. This phenomenon is known as “priming effect” (PE), [23].

Priming effects are strong short-term changes in the turnover of SOM caused by relatively moderate treatments of the soil e.g. fertilisation and addition of fresh organic C [7]. Addition of easily available

substances to soil provides C and energy sources to soil microorganisms [33]. Previous studies conducted in African countries (e.g. in Niger and Côte d'Ivoire) have reported 12–16% and 32% increase in native organic C mineralisation after organic C additions in forest and savannah soils respectively [13]. Under natural conditions [9], demonstrated that plant roots can increase mineralisation of native SOM by 383% above the respiration in control soil without plants. This suggests that energy-rich rhizodeposits can substantially increase SOM decomposition rate (Xiao et al., 2015; [14,27]. Accelerated SOM mineralisation can be attributed to stimulation of microbial activities in response to altered amounts of available C (Perveen et al., 2014; [4].

Soil microbial biomass (SMB) is an important component for SOM formation and regulates the cycling of organics and nutrients. Nutrient ratios in the refractory SOM are similar to those of soil microorganisms. This means that a large proportion of the SOM pool originates from microbial detritus, rather than directly from recalcitrant plant material [26]. The need to study PE in tropical soils is justified by the

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